

WHAT IS CLAIMED IS:

1. A multi-component catalyst system for the polycondensation of a polyester comprising the element germanium and one or more catalyst enhancers selected from the group of elements consisting of aluminium, silicon, molybdenum, manganese, lithium and combinations thereof, excepting the combination of germanium and lithium only, said elements being in the form of polycondensation compatible elements, compounds, acids, bases, salts, compositions, oxides or organic complexes.
- 10 2. A multi-component catalyst system as claimed in claim 1 wherein the monomer is bis-hydroxy-ethyl terephthalate, which is polycondensed to produce polyethylene terephthalate.
- 15 3. A catalyst system as claimed in claim 2 wherein the enhancer is aluminium.
4. A catalyst system as claimed in claim 2 wherein the enhancer is silicon.
5. A catalyst system as claimed in claim 2 wherein the enhancer is molybdenum.
- 20 6. A catalyst system as claimed in claim 2 wherein the enhancer is manganese.
7. A catalyst system as claimed in claim 2 wherein the enhancer is lithium and one or more of aluminium, silicon, molybdenum and manganese.
- 25 8. A catalyst system as claimed in claim 2 wherein the enhancer is two or more of aluminium, silicon, molybdenum, manganese and lithium.
- 30 9. A catalyst system as claimed in claim 2 wherein germanium and aluminium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of aluminium in the polyethylene terephthalate is in the range from 1 part per million to 400 parts per million.
- 35 10. A catalyst system as claimed in claim 9 wherein the level of germanium is 5 to 100 parts per million and the level of aluminium is 20 to 200 parts per million.

11. A catalyst system as claimed in claim 9 wherein the level of germanium is 5 to 60 parts per million and the level of aluminium is 60 to 150 parts per million.
12. A catalyst system as claimed in claim 2 wherein germanium and silicon are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of silicon in the polyethylene terephthalate is in the range from 1 to 400 parts per million.
13. A catalyst system as claimed in claim 12 wherein the level of germanium is 10 to 80 parts per million and the level of silicon is 10 to 200 parts per million.
14. A catalyst system as claimed in claim 12 wherein the level of germanium is 20 to 60 parts per million and the level of silicon is 20 to 150 parts per million.
15. A catalyst system as claimed in claim 9 wherein germanium and molybdenum are selected and the level of germanium in the polyethylene terephthalate is 1 to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is 1 to 200 parts per million.
16. A catalyst system as claimed in claim 15 wherein the level of germanium is 1 to 100 parts per million and the level of molybdenum is 1 to 100 parts per million.
17. A catalyst system as claimed in claim 15 wherein the level of germanium is 5 to 60 parts per million and the level of molybdenum is 1 to 20 parts per million.
18. A catalyst system as claimed in claim 2 wherein germanium and manganese are selected and the level of germanium in the polyethylene terephthalate is 1 to 200 parts per million and the level of manganese in the polyethylene terephthalate is 1 to 400 parts per million.
19. A catalyst system as claimed in claim 18 wherein the level of germanium is 10 to 80 parts per million and the level of manganese is 10 to 200 parts per million.
20. A catalyst system as claimed in claim 18 wherein the level of germanium is 20 to 60 parts per million and the level of manganese is 20 to 150 parts per million.
21. A catalyst system as claimed in claim 2 wherein germanium, aluminium and

silicon are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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22. A catalyst system as claimed in claim 2 wherein germanium, aluminium and molybdenum are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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23. A catalyst system as claimed in claim 2 wherein germanium, aluminium and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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24. A catalyst system as claimed in claim 2 wherein germanium, aluminium and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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25. A catalyst system as claimed in claim 2 wherein germanium, silicon and molybdenum are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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26. A catalyst system as claimed in claim 2 wherein germanium, silicon and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon

in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

5 27. A catalyst system as claimed in claim 2 wherein germanium, silicon and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range 10 from 1 part per million to 200 parts per million.

28. A catalyst system as claimed in claim 2 wherein germanium, molybdenum and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the 15 level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

20 29. A catalyst system as claimed in claim 2 wherein germanium, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

25 30. A catalyst system as claimed in claim 2 wherein germanium, manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts 30 per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

35 31. A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon and molybdenum are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per

million to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

32. A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

33. A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

34. A catalyst system as claimed in claim 2 wherein germanium, silicon, molybdenum and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

35. A catalyst system as claimed in claim 2 wherein germanium, silicon, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

36. A catalyst system as claimed in claim 2 wherein germanium, molybdenum, manganese and lithium are selected and the level of germanium in the polyethylene

terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the 5 polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

37. A catalyst system as claimed in claim 2 wherein germanium, aluminium, molybdenum and manganese are selected and the level of germanium in the polyethylene 10 terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per 15 million.

38. A catalyst system as claimed in claim 2 wherein germanium, aluminium, manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the 20 level of aluminium is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

25 39. A catalyst system as claimed in claim 2 wherein germanium, silicon, molybdenum and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 30 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

40. A catalyst system as claimed in claim 2 wherein germanium, aluminium, molybdenum and lithium are selected and the level of germanium in the polyethylene 35 terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1

part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

41. A catalyst system as claimed in claim 2 wherein germanium, silicon, 5 manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene 10 terephthalate is in the range from 1 part per million to 200 parts per million.

42. A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon, manganese and molybdenum are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per 15 million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is in the range from 1 20 part per million to 200 parts per million.

43. A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon, manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per 25 million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per 30 million to 200 parts per million.

44. A catalyst system as claimed in claim 2 wherein germanium, silicon, manganese, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per 35 million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the

polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

5        45.      A catalyst system as claimed in claim 2 wherein germanium, aluminium, silicon, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from  
10      1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

15      46.      A multi-component catalyst system for the polycondensation of a polyester comprising the element germanium and one or more catalyst enhancers selected from the group of elements consisting of silicon, molybdenum, manganese, lithium and combinations thereof, excepting the combination of germanium and lithium only, said elements being in the form of polycondensation compatible elements, compounds, acids, bases, salts, compositions, oxides or organic complexes.

20      47.      A multi-component catalyst system as claimed in claim 46 wherein the monomer is bis-hydroxy-ethyl terephthalate, which is polycondensed to produce polyethylene terephthalate.

25      48.      A catalyst system as claimed in claim 47 wherein the enhancer is silicon.

49.      A catalyst system as claimed in claim 47 wherein the enhancer is molybdenum.

30      50.      A catalyst system as claimed in claim 47 wherein the enhancer is manganese.

51.      A catalyst system as claimed in claim 47 wherein the enhancer is lithium and one or more of silicon, molybdenum and manganese.

35      52.      A catalyst system as claimed in claim 47 wherein the enhancer is two or more of silicon, molybdenum, manganese and lithium.

53. A catalyst system as claimed in claim 47 wherein germanium and silicon are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of silicon in the polyethylene terephthalate is in the range from 1 to 400 parts per million.

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54. A catalyst system as claimed in claim 47 wherein germanium and molybdenum are selected and the level of germanium in the polyethylene terephthalate is 1 to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is 1 to 200 parts per million.

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55. A catalyst system as claimed in claim 47 wherein germanium and manganese are selected and the level of germanium in the polyethylene terephthalate is 1 to 200 parts per million and the level of manganese in the polyethylene terephthalate is 1 to 400 parts per million.

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56. A catalyst system as claimed in claim 46 wherein germanium, silicon and molybdenum are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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57. A catalyst system as claimed in claim 46 wherein germanium, silicon and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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58. A catalyst system as claimed in claim 46 wherein germanium, silicon and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

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59. A catalyst system as claimed in claim 46 wherein germanium, molybdenum

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and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

60. A catalyst system as claimed in claim 46 wherein germanium, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

61. A catalyst system as claimed in claim 46 wherein germanium, manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

62. A catalyst system as claimed in claim 47 wherein germanium, silicon, molybdenum and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

63. A catalyst system as claimed in claim 47 wherein germanium, silicon, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

64. A catalyst system as claimed in claim 47 wherein germanium, molybdenum,

manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of molybdenum is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range 5 from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

65. A catalyst system as claimed in claim 47 wherein germanium, silicon, 10 molybdenum and manganese are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 15 part per million to 200 parts per million and the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

66. A catalyst system as claimed in claim 47 wherein germanium, silicon, manganese and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the 20 level of silicon is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

67. A catalyst system as claimed in claim 47 wherein germanium, silicon, manganese, molybdenum and lithium are selected and the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of silicon is in the range from 1 part per million to 200 parts per million, the level of manganese in the polyethylene terephthalate is in the range 25 from 1 part per million to 200 parts per million, the level of molybdenum in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

68. A multi-component catalyst system for the polycondensation of a polyester comprising the element germanium and the catalyst enhancers aluminium and lithium, said elements being in the form of polycondensation compatible elements,

compounds, acids, bases, salts, compositions, oxides or organic complexes.

69. A multi-component catalyst system as claimed in claim 68 wherein the monomer is bis-hydroxy-ethyl terephthalate, which is polycondensed to produce  
5 polyethylene terephthalate.

70. A catalyst system as claimed in claim 68 wherein the level of germanium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million, the level of aluminium in the polyethylene terephthalate is in the range  
10 from 1 part per million to 200 parts per million and the level of lithium in the polyethylene terephthalate is in the range from 1 part per million to 200 parts per million.

71. A catalyst system as claimed in claim 68 wherein the level of germanium is 5 to 100 parts per million, the level of aluminium is 20 to 200 parts per million and the level of lithium is 10 to 80 parts per million.  
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72. A catalyst system as claimed in claim 68 wherein the level of germanium is 5 to 30 parts per million, the level of aluminium is 60 to 150 parts per million and the  
20 level of lithium is 20 to 70 parts per million.

73. A catalyst system as claimed in claim 1 wherein the aluminium is incorporated in the catalyst system as a phenoxide, a lactate, a stearate, a glycolate, an oxalate, a citrate or a tartrate.  
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74. A catalyst system as claimed in claim 1 wherein the lithium is incorporated in the catalyst system as a hydroxide, an acetate, a citrate, a carbonate or an oxalate.

75. A catalyst system as claimed in claim 46 wherein the aluminium is incorporated in the catalyst system as a phenoxide, a lactate, a stearate, a glycolate, an oxalate, a citrate or a tartrate.  
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76. A catalyst system as claimed in claim 46 wherein the lithium is incorporated in the catalyst system as a hydroxide, an acetate, a citrate, a carbonate or an oxalate.  
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77. A catalyst system as claimed in claim 68 wherein the aluminium is incorporated in the catalyst system as a phenoxide, a lactate, a stearate, a glycolate, an

oxalate, a citrate or a tartrate.

78. A catalyst system as claimed in claim 68 wherein the lithium is incorporated in the catalyst system as a hydroxide, an acetate, a citrate, a carbonate or an oxalate.